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Prevalence and severity of asthma and allergies in schoolchildren in Lhasa, Tibet

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Clinical and Experimental Allergy

Summary

Background The International Study of Asthma and Allergies in Childhood (ISAAC) demonstrated that large variations existed in the prevalence of symptoms of asthma, allergic rhinoconjunctivitis and eczema throughout the world and that environmental factors and lifestyle customs are major determinants of the prevalence and severity of these diseases. However, the relevant data about children living at high-altitude locations were considered to be underreported.

Objective The ISAAC Phase III programme was carried out in Lhasa, the Tibetan Autonomous Region in China, at an elevation of 3658 m above sea level to examine the occurrence of asthma, allergic rhinoconjunctivitis and eczema in schoolchildren aged 13–14 years.

Methods All 3196 schoolchildren in eight public junior high schools in urban Lhasa who were confirmed to be 13–14 years old were invited and participated in both written and video questionnaire investigations, among which 3190 pieces of data (49.8% of boys and 50.2% of girls) were validated and analysed.

Results Among the overall observations, the prevalence of 'having ever experienced wheezing', 'current wheezing' and 'diagnosed to have asthma' was 1.4%, 0.8% and 1.1%, respectively. The prevalence of current exercise-induced asthma and current nocturnal cough was 7.1% and 4.6%, respectively. The current prevalence of allergic rhinoconjunctivitis and eczema was 5.2% and 0.4%, respectively. In addition, the prevalence of rhinoconjunctivitis symptoms during the past 12 months showed no discernable differences throughout the year. **Conclusion** The prevalence of asthma, allergic rhinoconjunctivitis and eczema over the past 12 months was the lowest among the centres, that performed ISAAC worldwide.

Keywords allergies, asthma, high altitude, schoolchildren, The International Study of Asthma and Allergies in Childhood (ISAAC)

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Introduction

The International Study of Asthma and Allergies in Childhood (ISAAC) was designed to investigate childhood asthma, allergic rhinoconjunctivitis and eczema at the population level with the aim of making international comparisons of the prevalence and severity of these disorders, thereby forming the basis for studies investigating the role of possible modifiable environmental factors that may ultimately lead to a reduction in the personal burden of these diseases [1]. ISAAC attracted worldwide interest and over 700 000 schoolchildren from 156 centres in 56 countries participated in the Phase I project. The

evidences that large variations exist in the prevalence of symptoms of these disorders throughout the world and that environmental factors and lifestyle customs are major determinants of the prevalence and severity of these diseases were demonstrated by the ISAAC Phase I project [2, 3]. However, the relevant data about children living at high-altitude locations were considered to be underreported [4].

Around 25% of the land surface of the earth is covered by mountains and approximately 140 million persons permanently reside and hundred thousands of newcomers temporarily live and work at elevations above 2500 meters above the sea level (m) [5]. While this is only a small fraction of the world's population, it comprises a

sizable proportion of population in certain countries or regions. In addition, the number of high-altitude residents will most likely increase as a result of population growth and active migration in many of these regions. The high-altitude natives have produced their particular adaptive patterns in physiological phenotypes while residing at high altitude for thousand generations [5, 6]. In addition, the newcomers also tend to become adapted to suitable lifestyles at high altitude after living and working there for many years [6]. The high-altitude environment is harsh, with substantial decreases in the inspiratory oxygen pressure, barometric pressure, relative humidity and temperature and an increase in solar radiation. On the other hand, it is well known that high-altitude areas also tend to be therapeutic sites for asthmatic patients because such climate conditions often lead to a clinical improvement in asthmatic symptoms [7, 8], probably due to a reduction or absence of pollutant exposure, pollen and mite concentrations [9, 10] in addition to modifications of the bronchial responsiveness [11] and airway inflammation [12] of asthmatic patients at a high altitude.

Therefore, information on the prevalence and severity of asthma, allergic rhinoconjunctivitis and eczema at a high altitude is absolutely essential data to elucidate an accurate 'global' picture of these diseases, and thus facilitating the goal of reaching the three aims of the ISAAC programme [1, 2]. For these reasons, a survey regarding the prevalence and severity of childhood asthma, allergic rhinoconjunctivitis and eczema was carried out in Lhasa at an elevation of 3658 m in the Tibet Autonomous Region of China according to the ISAAC Phase III guidelines [1].

Methods and subjects

Setting and populations

The current survey was conducted in the urban area of Lhasa from 14 September to 7 December 2001. Lhasa is the capital of the Tibetan Autonomous Region in China. It lies at 29°41.76'N 91°9.54'E in an area known as the 'Lhasa Valley'. Its altitude is about 3658 m, with a barometric pressure of 490 mmHg, and the mountains around it rise to 5500 m. At the time of our fieldwork, the population in urban Lhasa was about 134 000 in an area of 523 km², which is composed of multi-ethnicities including 87% Tibetans, 10% Han Chinese (Han) and 3% other minority ethnic groups, such as Hui, Loba, etc. Tibetans include the natives in Tibet and they have been on the Tibetan Plateau for more than 50 000 years [5]. Han is the major ethnicity in the mainland of China and they are newcomers to Tibet over the past 50 years. Han usually work and live in Tibet temporarily for about 10 years and then returned back to their hometowns in China. Hui is a small Muslim ethnic group in Lhasa with a population of <3000 and they have resided in Lhasa for <200 years.

According to the ISAAC protocol [1], a sample size with at least 3000 schoolchildren is required to determine statistical significance with a strong enough statistical power. Therefore, all eight public junior high schools accessible in the urban area of Lhasa were recruited for our study and all 3196 students, ranging in age from 13 to 14 years, were invited to participate in the current investigation.

Preparation for fieldwork

The investigation was registered at the ISAAC International Data Center and an area code of 111006 was given. This ISAAC Phases III project was coordinated by the national coordinator (Y. Z. Chen) in Capital Institute of Pediatrics of Beijing (China) and it was approved by the Education Committee of Lhasa City and the Ethnic Committee of the People's Hospital of Tibet Autonomous Region (Lhasa, Tibet). Two fieldwork investigators (Y. Droma and M. Shan) were trained for the operation of the ISAAC Phase III in the Capital Institute of Pediatrics of Beijing, where the national coordination headquarters of ISAAC of China is located and it has so far successfully operated ISAAC Phase I in five cities in China [2, 3].

In the urban area of Lhasa, all Tibetan and Hui schoolchildren are officially educated bilingually in the Tibetan and Chinese languages, while all Han schoolchildren are generally educated only in the Chinese language. The Chinese comprehensive level of all the current schoolchildren was similar to the same-age schoolchildren in the mainland of China. Therefore, the Chinese version of the standard ISAAC core questionnaire and the international version of the asthma video tape (AVQ3.0) with its Chinese questionnaire sheet were chosen for use in the current investigation in Lhasa. All these questionnaire materials in the Chinese version, which have been widely used in ISAAC Phase I in China nationwide [2, 3], were kindly provided by the Capital Institute of Pediatrics of Beijing.

Informed consent was obtained from each participant through school administrators.

Fieldwork protocol

The ethnicity was determined by self-reporting and thereafter was confirmed by the Tibetan staff and teachers based on the characteristic ethnic names. The students in different classes were organized into one classroom to complete the core written questionnaire under the supervision of their class teachers and our staff. Subsequently, they were introduced into a television room where the project staff read out the instructions to the students and distributed the answer sheet for the video questionnaire. The AVQ3.0 video showed the clinical signs and symptoms of asthma after each of the questions [13]. After each scene, the students recorded whether their breathing had

ever been affected in a manner similar to that shown in the video and described on the answer sheet. This video questionnaire took about 7–10 min and the terms asthma or wheezing were not mentioned at any stage. For students who were absent from school during our visit, the questionnaires were administered to them during our next visit.

The contents of the standard ISAAC core questionnaire and the AVQ3.0 video questionnaire have been described elsewhere [1, 13, 14]. In Phase One, eczema as defined by the questions in the core questionnaire was called atopic eczema, but is now referred to as eczema, as recommended by the World Allergy Organization [15].

Data analysis

The collected questionnaires were coded following the protocol of the ISAAC Coding and Data Transfer Manual. The data were double entered into a database and then were submitted to the ISAAC International Data Center to verify the quality. Coding errors, omissions and any inconsistencies in the demographic information were corrected.

The prevalence was a result of dividing the number of positive responses by the total number of responses to each question for the written and video questionnaires separately. We compared the prevalence between the boys and girls independent of the ethnicity as well as between Tibetan and Han independent of sex among the total analysed data. In order to avoid any type II errors, no comparisons were made with the Hui samples due to the very small sample size. The data were analysed through StatPages.net web site [16]. Fisher's exact probability test was used to compare the prevalence of symptoms because the margin was very uneven and there was a small value (<5) for some positive answers for the video questionnaire (AVQ 3.0). The odds ratio was calculated as the cross-product ratio of a particular symptom in one category compared with that in its comparing category. An approximate 95% confidence interval (CI) of the odds ratio was also given.

The monthly variation in the prevalence in allergic rhinoconjunctivitis symptoms is shown by a graph (Fig. 1), and the significance of the variation throughout the last 12 months was analysed by a 12×2 contingency table (degree of freedom = 11).

Results

Participants

Overall, 3196 students who were confirmed to be 13–14-years old participated in the investigation. The data of six students were excluded due to missing demographic data. According to the birth-date information in the question-

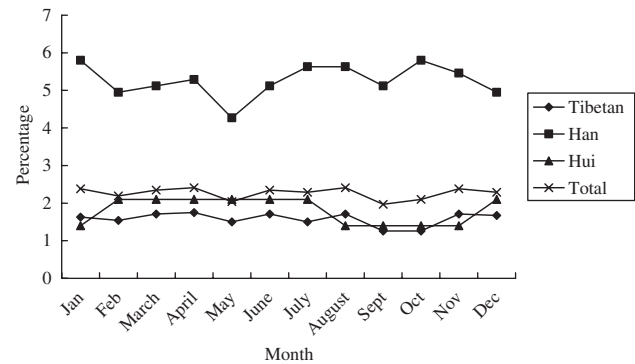


Fig. 1. The seasonal variations of the prevalence of the rhinoconjunctivitis during the 12 months before the investigation in schoolchildren in Lhasa (3658 m, 490 mmHg barometric pressure), Tibet.

naire, the median age was 13.8 years at the date of the interview. The response rate was 100% as the students were interviewed in the classroom under the supervision of the ISAAC staff and school teachers, and those who were absent from school at the date of our first visit were followed-up during our next visit. No students refused to answer the questionnaires.

From the grand total of 3190 (boys 49.8%, girls 50.2%) students, Tibetans (77.1%, boys 1171, girls 1290) accounted for the highest proportion among the participants, followed by Han (18.4%, boys 324, girls 262) and Hui (4.5%, boys 94, girls 49).

Written questionnaire

Self-reported prevalence. Table 1 provides the self-reported prevalence of the symptoms regarding asthma, allergic rhinoconjunctivitis and eczema in the present investigation. We defined all the symptoms, that occurred in the past 12 months as current symptoms. Among the overall observations, the prevalence of 'having ever experienced wheezing', 'current wheezing' and 'asthma diagnosed by doctor' was 1.4%, 0.8% and 1.1%, respectively. The prevalence of current exercise-induced asthma and current nocturnal cough was 7.1% and 4.6%, respectively. Rhinoconjunctivitis was the most common problem, with a history of previous nasal problems in 9.3%, current nasal problems in 5.2%, current itchy-watery eyes in 1.5% and rhinoconjunctivitis diagnosed by doctor in 1.3%. The symptoms concerning eczema were minor complaints with a history of a recurrent rash in 0.9%, a current recurrent rash in 0.4%, itchy rash-affected identified parts of the body (such as the folds of the elbows, behind the knees, in front of the ankles, under the buttocks or around the neck, ears or eyes) in 0.3% and eczema diagnosed by doctor in 1.4%. The prevalence of 'having ever experienced wheezing', 'current exercise-induced asthma' and 'recurrent rash' showed significant

Table 1. Prevalence of the asthma, allergic rhinoconjunctivitis and eczema among 3190 schoolchildren in Lhasa*

	Total (<i>n</i> = 3190)	Boys (<i>n</i> = 1589)	Girls (<i>n</i> = 1601)	<i>P</i> [†] OR (95% CI) [‡]	Tibetan (<i>n</i> = 2461)	Han (<i>n</i> = 586)	Hui (<i>n</i> = 143)	<i>P</i> [§] OR (95% CI) [§]
Responses for asthma								
Having ever experienced wheezing	46	30	16	0.013	31	9	6	0.132
	1.4	1.9	1.0	1.9 (1.0–3.5)	1.3	1.5	4.2	1.2 (0.6–2.6)
Wheezing in the past 12 months	24	15	9	0.076	17	3	4	0.215
	0.8	0.9	0.6	1.7 (0.7–3.8)	0.7	0.5	2.8	0.7 (0.2–2.5)
Diagnosed to have asthma	35	18	17	0.132	27	8	0	0.139
	1.1	1.1	1.1	1.1 (0.5–2.1)	1.1	1.4	–	1.2 (0.6–2.8)
Exercise-induced asthma in the past 12 months	226	103	123	0.023	108	107	11	<0.0001
	7.1	6.5	7.7	0.8 (0.6–1.1)	4.4	18.3	7.7	5.2 (4.0–6.8)
Nocturnal cough in the past 12 months	147	75	72	0.064	105	39	3	0.005
	4.6	4.7	4.5	1.1 (0.8–1.5)	4.3	6.7	2.1	1.6 (1.1–2.3)
Responses for rhinoconjunctivitis								
Ever experienced nasal problems	297	150	147	0.047	179	102	16	<0.0001
	9.3	9.4	9.2	1.0 (0.8–1.3)	7.3	17.4	11.2	2.7 (2.1–3.5)
Nasal problems in the past 12 months	165	87	78	0.047	78	73	14	<0.0001
	5.2	5.5	4.9	1.1 (0.8–1.5)	3.2	12.5	9.8	4.3 (3.2–5.9)
Experienced itchy-watery eyes in the past 12 months	49	21	28	0.071	32	13	4	0.038
	1.5	1.3	1.7	0.8 (0.4–1.3)	1.3	2.2	2.8	1.7 (0.9–3.3)
Diagnosed to have rhinoconjunctivitis	43	24	19	0.090	23	17	3	0.0004
	1.3	1.5	1.2	1.3 (0.7–2.3)	0.9	2.9	2.1	3.2 (1.7–5.8)
Responses for eczema								
Recurrent rash 'ever'	30	16	14	0.135	22	5	3	0.194
	0.9	1.0	0.9	1.2 (0.6–2.4)	0.9	0.9	2.1	1.0 (0.4–2.8)
Recurrent rash in the past 12 months	12	8	2	0.043	8	3	1	0.213
	0.4	0.5	0.1	4.1 (1.0–16.0)	0.3	0.5	0.7	1.6 (0.4–5.9)
Rash specified distributions [¶]	10	5	5	0.246	8	2	0	0.302
	0.3	0.3	0.3	1.0 (0.3–3.5)	0.3	0.3	–	1.0 (0.2–4.5)
Diagnosed eczema	45	25	20	0.089	27	15	3	0.005
	1.4	1.6	1.2	1.3 (0.7–2.3)	1.1	2.6	2.1	2.4 (1.3–4.4)

*The numbers in the first line indicate the numbers of positive answer (*n*) and in the second line indicate the prevalence of the symptoms (%). No comparison was applied to Hui samples in order to avoid a type II error due to the small sample size.

[†]The Fisher's exact probability test was used to compare the prevalence of symptoms.

[‡]The strength of the prevalence in boys to girls was evaluated by the odds ratio (OR) with a 95% confidence interval (95% CI).

[§]The strength of the prevalence in Han to Tibetan students was evaluated by the OR with a 95% CI.

[¶]Has this itchy rash at any time affected any of the following places: the folds of the elbows, behind the knees, in front of the ankles, under the buttocks, or around the neck, ears or eyes?

differences between boys and girls ($P=0.013$, 0.023 and 0.043, respectively). Meanwhile, significant differences were also observed between Tibetan and Han students in terms of the prevalence of current exercise-induced asthma ($P<0.0001$) and current nocturnal cough ($P=0.005$). Noticeably, all the symptoms regarding allergic rhinoconjunctivitis showed significant differences in prevalence between Tibetan and Han students (Table 1). In the case of eczema symptoms, only eczema diagnosed by a doctor was significantly higher in Han than Tibetan students (Table 1, $P=0.005$).

Severity. Table 2 shows the severity of asthma, allergic rhinoconjunctivitis and eczema in the present investigation. Among the total of 3190 students, the asthma

symptoms did not seriously threaten the daily activities of the schoolchildren, with a prevalence of wheezing attacks more than four times in 0.1%, sleep disturbed by wheezing in 0.3% and speech limited by wheezing in 0.3% in the past 12 months. In the past 12 months, rhinoconjunctivitis symptoms affected 3.0% of the students in their daily activities and eczema itchy symptom woke 0.6% of the children during their sleep. There were no significant differences in the severity of these frequencies between the boys and girls (all $P>0.05$). However, the rhinoconjunctivitis affected more Han (6.1%) than Tibetan (2.2%) students in their daily activities.

Seasonal variations of the prevalence of rhinoconjunctivitis symptom. We plotted the monthly prevalence of the

Table 2. Prevalence of the severity of the asthma, allergic rhinoconjunctivitis and eczema among 3190 schoolchildren in Lhasa*

	Total (<i>n</i> = 3190)	Boys (<i>n</i> = 1589)	Girls (<i>n</i> = 1601)	<i>P</i> [†] OR (95% CI) [‡]	Tibetan (<i>n</i> = 2461)	Han (<i>n</i> = 586)	Hui (<i>n</i> = 143)	<i>P</i> [†] OR (95% CI) [§]
Severity of asthma (in the past 12 months)								
1–3 attacks	25	14	11	0.132	19	2	4	0.134
	0.8	0.9	0.7	1.3 (0.6–2.8)	0.8	0.3	2.8	0.4 (0.1–1.8)
>4 attacks	3	1	2	0.377	2	1	0	0.377
	0.1	0.1	0.1	0.5 (0.05–5.31)	0.1	0.2	–	2.1 (0.2–22.0)
Sleep disturbed by wheezing	9	4	5	0.247	9	0	0	–
	0.3	0.3	0.3	0.8 (0.2–3.0)	0.4	–	–	–
Speech limited by wheezing	10	3	7	0.119	9	1	0	0.281
	0.3	0.2	0.4	0.4 (0.1–1.6)	0.4	0.2	–	0.5 (0.1–3.5)
Severity of rhinoconjunctivitis (in the past 12 months)								
Affecting daily activities	95	44	51	0.065	54	36	5	<0.0001
	3.0	2.8	3.2	0.9 (0.6–1.3)	2.2	6.1	3.5	2.9 (1.9–4.4)
Severity of eczema (in the past 12 months)								
Awake at night by itchy rash	20	9	11	0.162	16	4	0	0.218
	0.6	0.6	0.7	0.8 (0.3–2.0)	0.7	0.7	–	1.1 (0.3–3.2)

*The numbers in the first line indicate the numbers of positive answer (*n*) and in the second line indicate the prevalence of the symptom (%). No comparison was applied to the Hui samples in order to avoid a type II error due to the small sample size.

[†]Fisher's exact probability test was used to compare the prevalence of symptoms.

[‡]The strength of the prevalence in boys to girls was evaluated by the odds ratio (OR) with a 95% confidence interval (95% CI).

[§]The strength of the prevalence in Han to Tibetan students was evaluated by the OR with a 95% CI.

rhinoconjunctivitis over the last 12 months on a graph categorized by the ethnicities (Fig. 1) and found that the prevalence of rhinoconjunctivitis showed no discernable differences throughout the year for all participants. However, the Han students showed a higher prevalence than Tibetan students throughout the year.

Video questionnaire

The proportions of the ethnicity and gender of the students who completed the video questionnaire were the same as those for the written questionnaire. Among the 3190 students in the video questionnaire data, the prevalence of wheezing at rest, exercise-induced wheezing, nocturnal wheezing, nocturnal cough and severe wheezing was 0.3%, 1.2%, 0.03% (only one student), 1.4% and 0.3%, respectively (Table 3). There were no significant differences in the prevalence between the boys and girls. Except for severe wheezing ($P = 0.002$), there were also no significant differences in the prevalence between Tibetan and Han students. Surprisingly, no Hui students reported any positive answers for the video scenes in the current survey, probably due to the small number of Hui students. The prevalence of asthma symptoms as estimated by the video questionnaire was generally lower than those of the corresponding questions by the written questionnaire, probably because the video tended to show more severe asthma symptoms in the scenes [2, 3, 14].

Discussion

The worldwide ISAAC project provides a unique opportunity to assess the prevalence of self-reported asthma, allergic rhinoconjunctivitis and eczema in children at a high altitude by standard methods, and therefore, we could compare the outcomes with the corresponding prevalence reported by ISAAC project elsewhere either at the sea level or in lowland areas. In comparison with the self-completed ISAAC questionnaire data for 13–14-years-old schoolchildren worldwide [2, 3, 17], the prevalence of current wheezing in the urban areas of Lhasa was the lowest (0.8%) so far reported in the world. In addition, the symptoms indicating the severity of asthma were the lowest prevalence reported in the world, specifying that the wheezing attacks more than four times in the past 12 months were very low at 0.1%, the sleep disturbance due to wheezing in the past 12 months was low at 0.3%, the speech limitations due to severe wheezing was low at 0.3% and the asthma diagnosed by a doctor was only 1.1%. Moreover, the prevalence of current exercise-induced asthma (7.1%) and dry cough at night (4.6%) were also significantly lower in Lhasa than in most other centres in the world [3]. The current prevalence of allergic rhinoconjunctivitis was 5.2% and demonstrated no discernable difference throughout the year. The current prevalence of eczema was 0.4%, which was the lowest among the centres that participated in the ISAAC project worldwide [2, 17].

Table 3. Prevalence of the positive answers to the ISAAC video questionnaire (AVQ 3.0) in schoolchildren in Lhasa*

Scenes	Total (<i>n</i> = 3190)	Boys (<i>n</i> = 1589)	Girls (<i>n</i> = 1601)	<i>P</i> [†] OR (95% CI) [‡]	Tibetan (<i>n</i> = 2461)	Han (<i>n</i> = 586)	Hui (<i>n</i> = 143)	<i>P</i> [†] OR (95% CI) [§]
Wheezing at rest	8	5	3	0.217	6	2	0	0.288
	0.3	0.3	0.2	1.7 (0.4–6.9)	0.2	0.3	–	1.4 (0.3–6.9)
Exercise-induced wheezing	38	23	15	0.054	27	11	0	0.050
	1.2	1.5	0.9	1.6 (0.8–3.0)	1.1	1.9	–	1.7 (0.9–3.5)
Nocturnal wheezing	1	0	1	–	0	1	0	–
	0.03	–	0.06	–	–	0.2	–	–
Nocturnal cough	43	17	26	0.049	34	9	0	0.143
	1.4	1.1	1.6	0.6 (0.4–1.2)	1.4	1.5	–	1.1 (0.5–2.3)
Severe wheezing	9	3	6	0.166	3	6	0	0.002
	0.3	0.2	0.4	0.5 (0.1–2.0)	0.1	1.0	–	8.5 (2.7–27.0)

*The numbers in the first line indicate the numbers of positive answer (*n*) and in the second line indicate the prevalence of the symptoms (%). No comparison was applied to the Hui samples in order to avoid a type II error due to the small sample size.

[†]Fisher's exact probability test was used to compare the prevalence of symptoms.

[‡]The strength of the prevalence in boys to girls was evaluated by the odds ratio (OR) with a 95% confidence interval (95% CI).

[§]The strength of the prevalence in Han to Tibetan students was evaluated by the OR with a 95% CI.

A high altitude is always a particularly favourable environment for asthmatic patients. Sojourns in the high mountains have been recommended by specialists for patients with asthma for many decades [7]. Some asthmatic children living in mountain areas experienced a significant improvement in their daily symptoms and in the degree of bronchial obstruction [7, 18]. The reasons for such a phenomenon have been widely studied and explained as mainly being due to a reduction of pollutant exposure, pollen and mite concentrations [8, 10] and possibly being related to a reduction of local airway inflammation due to the hypoxia-induced T-lymphocyte decrease [12] and a protective role of higher levels of suprarrenal hormones and/or atrial natriuretic peptide [19]. The ISAAC Phase I report regarding the correlations of climate with the prevalence of asthma and allergic diseases also showed that altitude was negatively associated with asthma and allergic diseases [4]. Consistently, our data, which were obtained from a population-based epidemiological investigation by an international standard method, demonstrated that the 13–14-years old schoolchildren residing at high altitudes presented the lowest prevalence of asthma, rhinoconjunctivitis and eczema in the world.

The concentrations of mites and moulds in the environment have been linked epidemiologically to asthma and allergic disorders as key aeroallergens [20]. Kao *et al.* [21] reported that the subtropical climate with a high humidity in Taiwan and a high house dust mite concentration, especially in December, were the main reasons for a significant increase in asthma admission rates during the winter season. The average annual temperature in Lhasa is about 8 °C and the temperature variation between day and night is about 15.7 °C on average. The annual sunshine time reaches more than 3000 h. The annual rainfall is

500 mm and 85% of the rainfall usually occurs at night. The 'night rain' washes away the heat and dust of the day and thus cleans the streets. The outdoor relative humidity is 26% in February and 69% in August. All these climate characteristics probably result in a low concentration of mite and mould allergens in the environment (although we could not find direct evidence due to lack of data regarding this), thus resulting in less exposure of the population to these aeroallergens. Another reason that could explain the low asthma prevalence in schoolchildren is the fact that there is relatively less outdoor air pollution in Lhasa. In the urban area of Lhasa, there are few heavy industrial factories and automobiles (one vehicle/34 person) as of 2001. According to the state environmental protection administration of Lhasa in 2001, the average ambient concentration of suspended particulate matter (SPM) is about 193–268 µg/m³, equivalent to 'excellent' or 'good' air quality by the Chinese national ambient air quality standard guidelines for commercial areas. In this context, both cross-sectional and longitudinal studies showed air pollution to be associated with increased asthma morbidity and new cases of asthma [22, 23]. Outdoor air pollution may affect allergen-induced inflammation by initiating T-helper type 2 cell responses to antigens or by exacerbating such an inflammation in persons already sensitized [24]. Taking these facts into account, we propose that the characterized climate and the clean ambient air quality may likely be the major reasons for the low prevalence of asthma and allergic diseases in Lhasa.

Both genetic and environmental factors play important roles in the aetiology of childhood asthma and allergic diseases, and there is probably also a genetic susceptibility to the effects of environmental factors [25]. Tibetan and Han are different ethnical populations with their own

phenotype [5, 26] and genotype [5, 6] characteristics. The results in our investigation that showed a similar low prevalence of asthma and allergic diseases in both Tibetan and Han schoolchildren in high-altitude environments thus suggest an overwhelming environmental influence on the occurrence of these ailments. However, under particular stress circumstances, such as exercise, sleep and upper respiratory infection at a high altitude, the Tibetan students showed an advantageous resistance to the occurrence of these symptoms, thus resulting in lower exercise-induced asthma (4.4%), nocturnal cough (4.3%) and nasal problems (3.2%) compared with Han students (18.3%, 6.7% and 12.5%, respectively). In addition, the present video questionnaire demonstrated more Han (1.0%) than Tibetan (0.1%) students with severe wheezing. Therefore, further well-designed studies are needed to examine the associations of the low prevalence of asthma, allergic rhinoconjunctivitis and eczema in multi-ethnic populations in Lhasa city with respect to its environment, population genetics or the interaction of both.

Two reasons led us to use the ISAAC video questionnaire (AVQ3.0) in this investigation. One was that our participants were multi-ethnic students whose comprehensive level of understanding Chinese was different, despite officially being offered standard Chinese language education. The second reason was the unsure accuracy in understanding the symptoms described in the written questionnaire due to a low awareness of asthma among the local population. The ISAAC AVQ3.0 is a valid and reliable tool for assessing the prevalence of asthma in a population of diverse ethnic backgrounds [14], and it is fairly correlated with the written questionnaire on moderate wheeze at rest and exercise-induced wheeze [27]. In line with the findings of other reports [2, 3], our video investigation revealed a generally lower asthma prevalence than the written one for corresponding questions, because the video showed more severe typical asthma symptoms. Our results showed the same pattern as those reported in other papers [3]. The estimates by video questionnaire verified the validity and reliability of the results based on the written questionnaire among multi-ethnic schoolchildren in Lhasa in this investigation.

In summary, based on the ISAAC standard method, our data showed the prevalence of asthma, allergic rhinoconjunctivitis and eczema in high-altitude Lhasa to be the lowest among all centres that had previously performed the ISAAC worldwide. Environmental aspects such as high-altitude hypoxia, climatic features and less air pollution are highly suggested to be the possible contributing reasons for the low prevalence of asthma, allergic rhinoconjunctivitis and eczema in high-altitude Lhasa. Further studies are needed to examine the associations between the low prevalence of these diseases in Lhasa with respect to its environment and the genetic background of different ethnic groups or the interactions of both.

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